Driving Sustainable Innovation through Life Cycle Thinking

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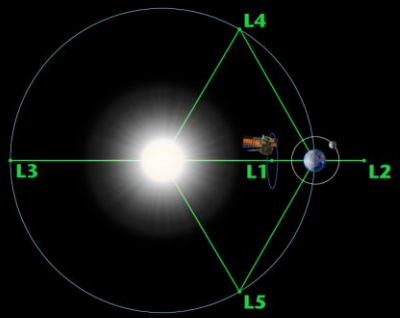
Sustainable Chemistry
3 November 2015



DSCOVR

Daily updates at
http://epic.gsfc.nasa.gov/

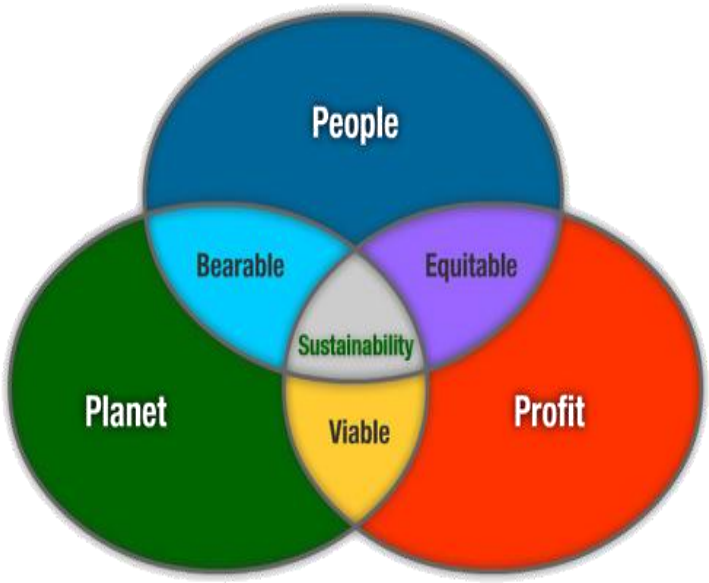
Impact equation

$$I = P * A * T$$

What is Sustainability?

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs

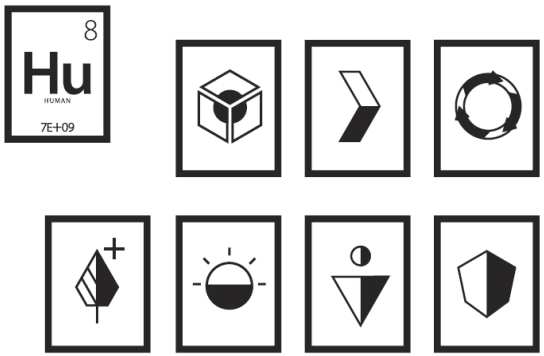
(Brundtland Commission)

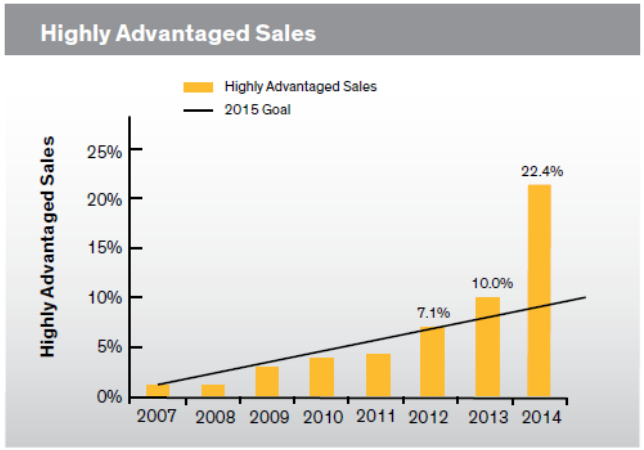


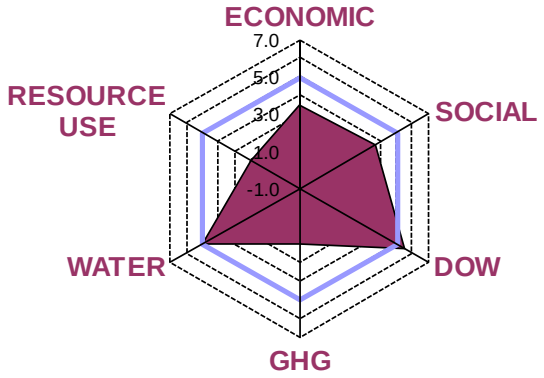
Dow's view of sustainability

We aim to advance the well-being of humanity by helping lead the transition to a sustainable planet and society.

Ways to bring in life-cycle thinking

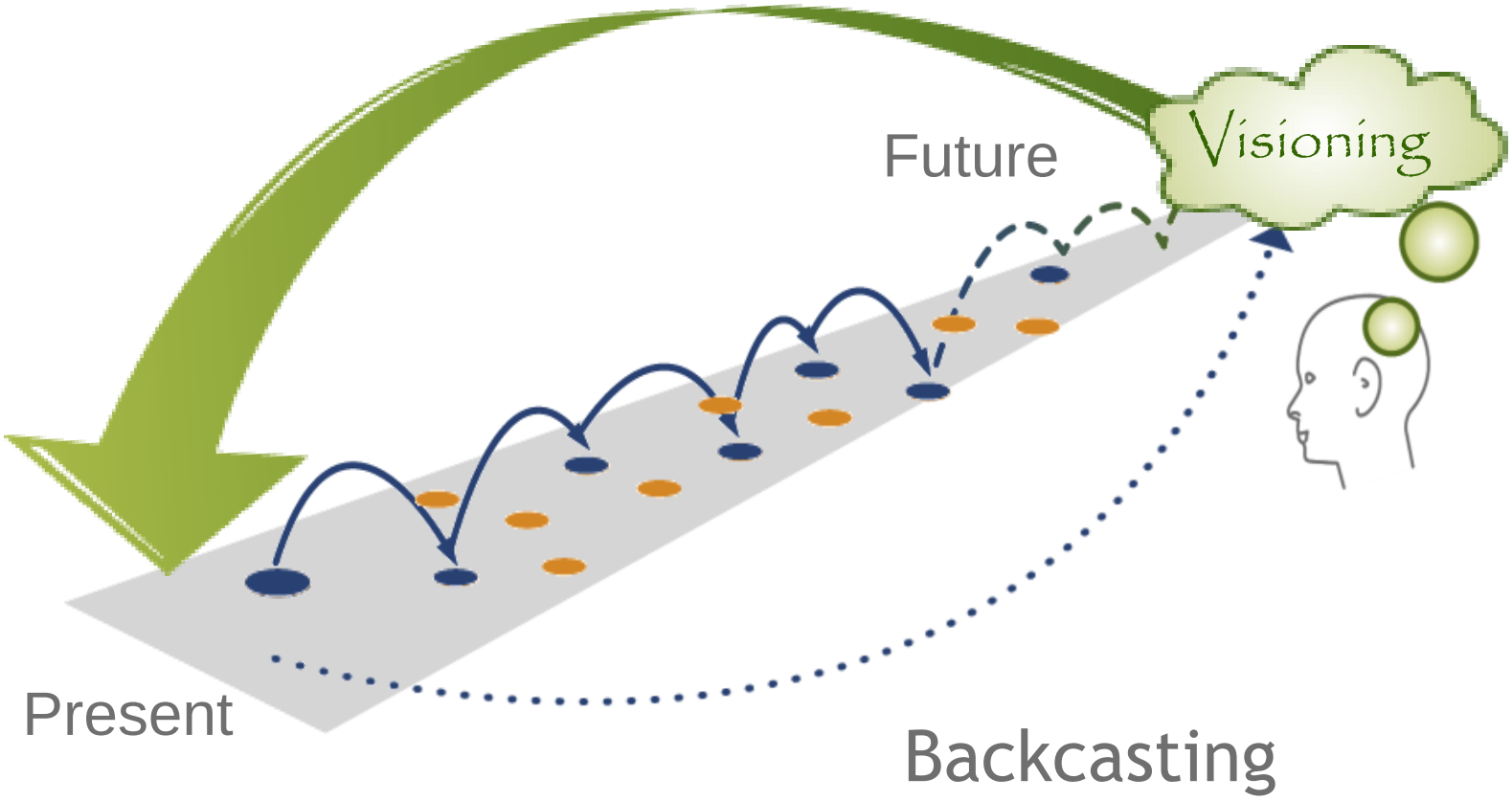






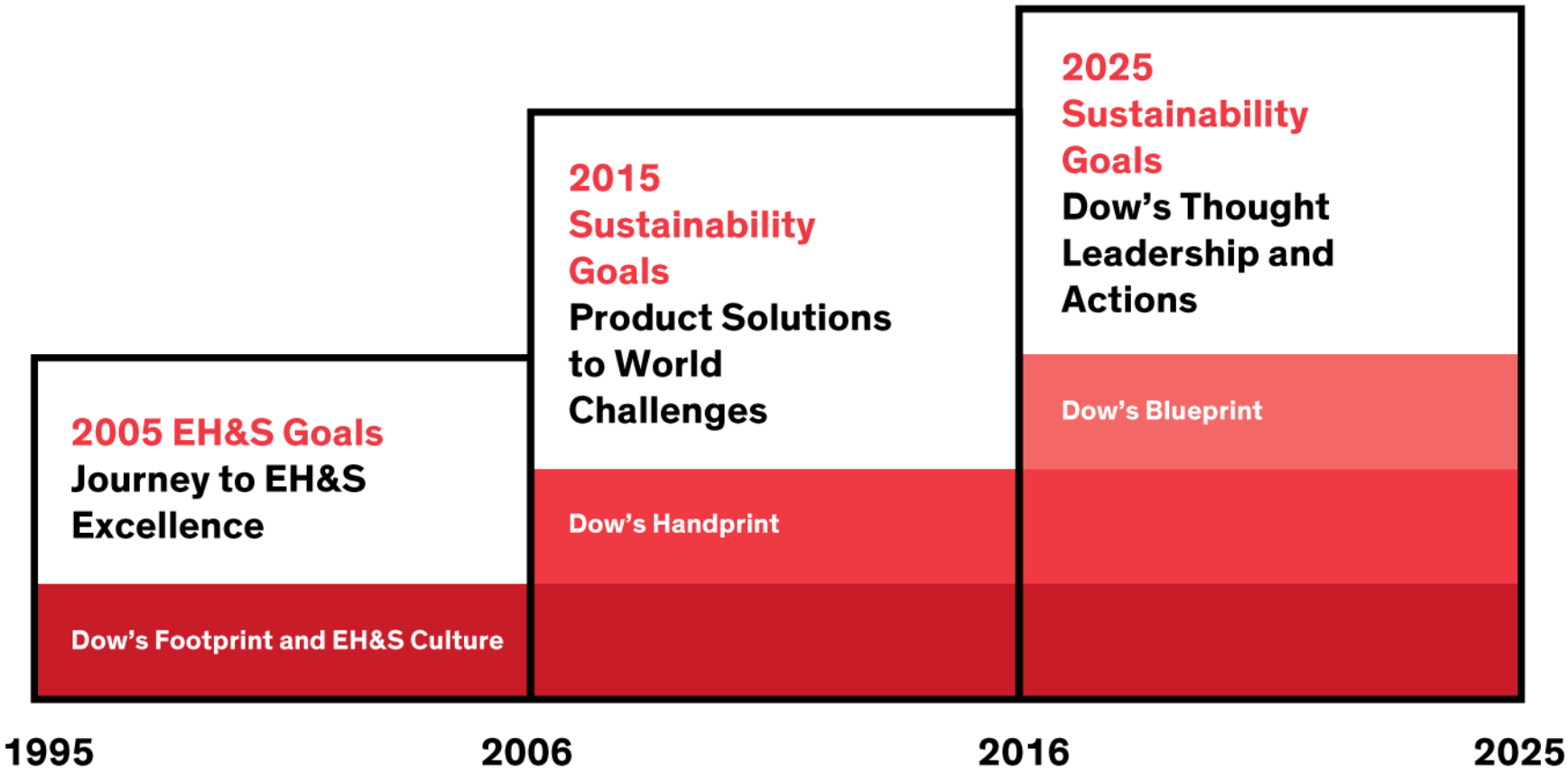
Helling, Richard “Driving sustainable innovation through life-cycle thinking”, Clean Technologies & Environmental Policy, (2015) DOI: 10.1007/s10098-015-0928-7

Plan with a **sustainable future** in mind



Source: The Natural Step

Evolution of Sustainability Goals



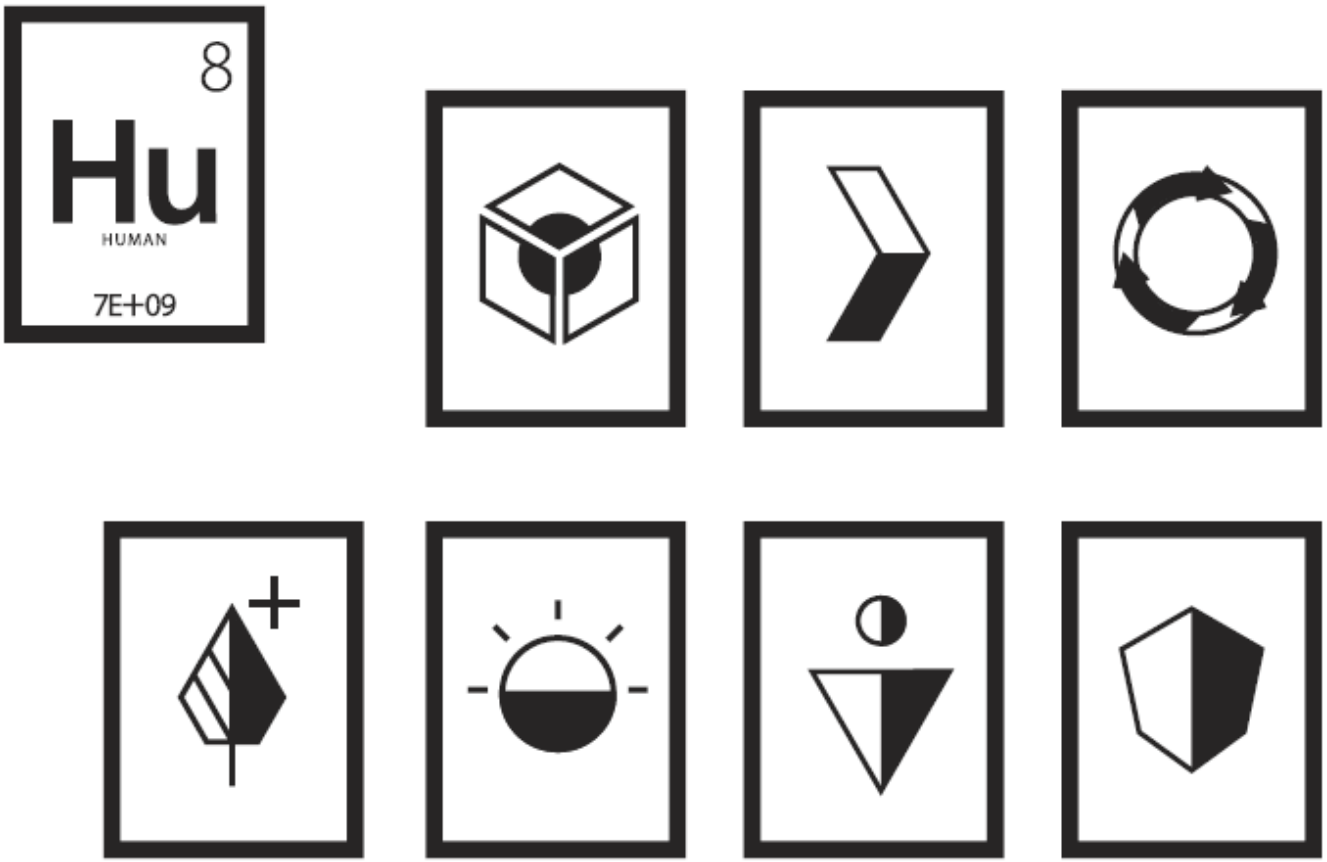
Footprint: World-leading operations and supply chain perfomance

Handprint: Products and services that help customers meet their challenges

Blueprint: Changes in technology, public policy, and the value chain that lead human society toward sustainability

http://www.dow.com/en-us/science-and-sustainability/sustainability-reporting/footprint-handprint-blueprint

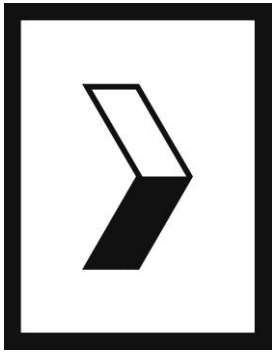
2025 Sustainability Goals



Redefining the role of business in society

http://www.dow.com/en-us/science-and-sustainability/sustainability-reporting

2025 Sustainability goal example: Breakthrough innovation



Goal:
Dow delivers breakthrough sustainable chemistry innovations that advance the well-being of humanity.

Some of the metrics & elements:

- Innovate to increase the net impact of products by **six fold**
- Ensuring energy & CO_2 benefits exceed our footprint by no less than **3:1**
- Assess the number of people positively impacted by Dow products and solutions
- Continue to improve, use and report its Sustainable Chemistry Index

http://www.dow.com/en-us/science-and-sustainability/sustainability-reporting/delivering-breakthrough-innovations

2015 Sustainable Chemistry Index goal: 10% “highly advantaged sales”

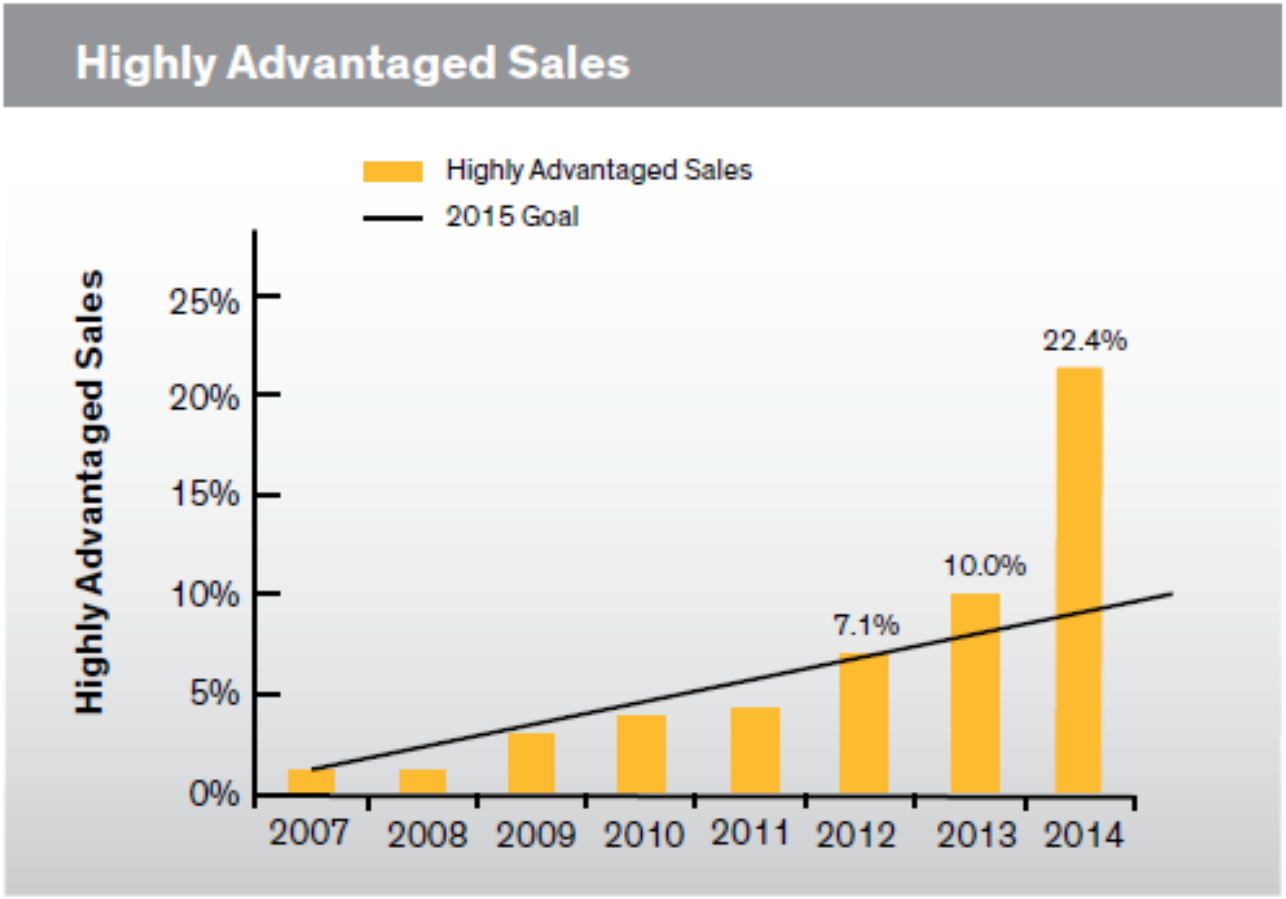
SCI: 8 sections, 40 total points

- **S1**: Renewable/Recycled Content
- **S2**: Resource Abundance & Mgmt
- **S3**: Manufacturing Efficiency
- **S4**: Environmental Life Cycle Benefit
- **S5**: Social Need
- **S6**: Manufacturing/Transport Risk
- **S7**: Product Application Risk
- **S8**: Public Policy/End of Life Risk

For more information:

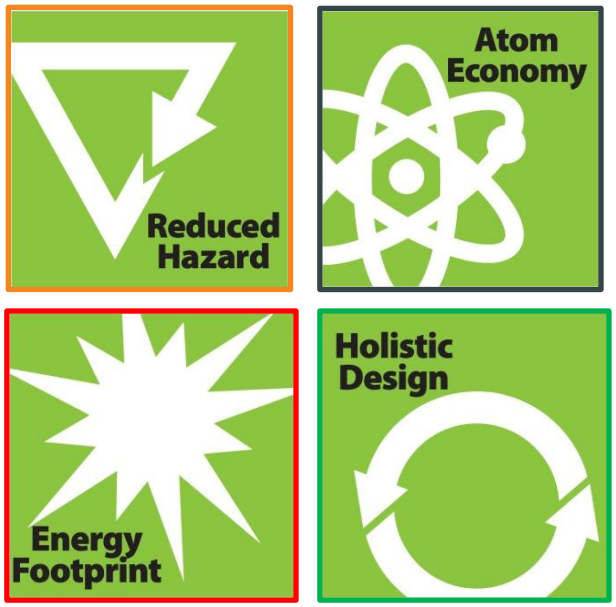
Hunter, Shawn & Anne Wallin “*The Sustainable Chemistry Index: Developing a Life Cycle View of the Dow Chemical Company Product Portfolio*” Proceedings of LCA XIV, San Francisco, October **2014**.

Met 2015 Sustainable Chemistry Index goal and more!

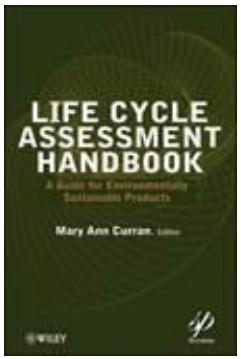


Principles of Green Chemistry & Engineering

Dow's "Principles of Sustainable Chemistry & Engineering"

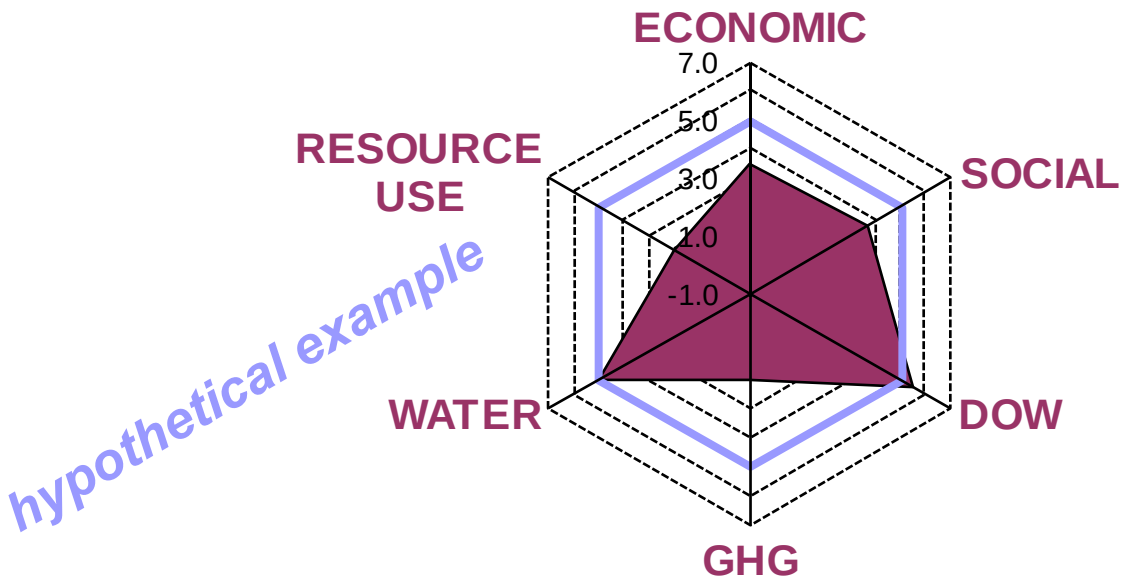


As found in



Dow Chemical Sustainability Footprint Tool©

23 questions compiled into 6 dimensions:



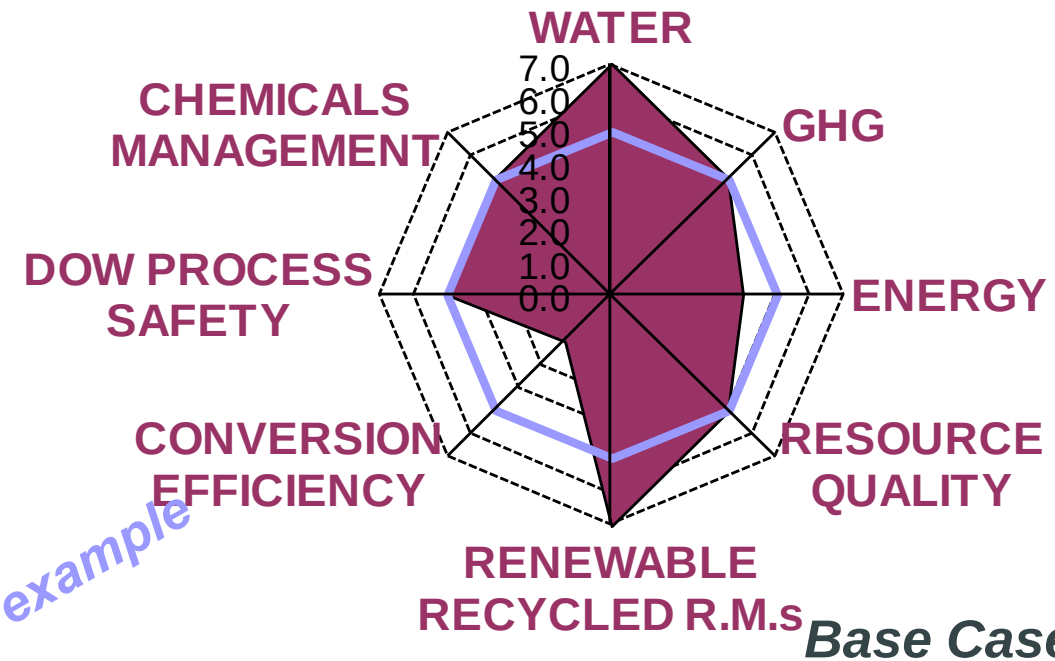
Base Case:

Project relative footprint (smaller is better):

David A. Russell & Dawn L. Shiang.
ACS Sustainable Chem. Eng., **2013**, *1* (1), pp 2–7
http://pubs.acs.org/doi/abs/10.1021/sc300131e

The “Dow” dimension the Tool

The Dow dimension considers 8 aspects:



Base Case:

Project relative footprint (smaller is better):

Example of DCSFT use

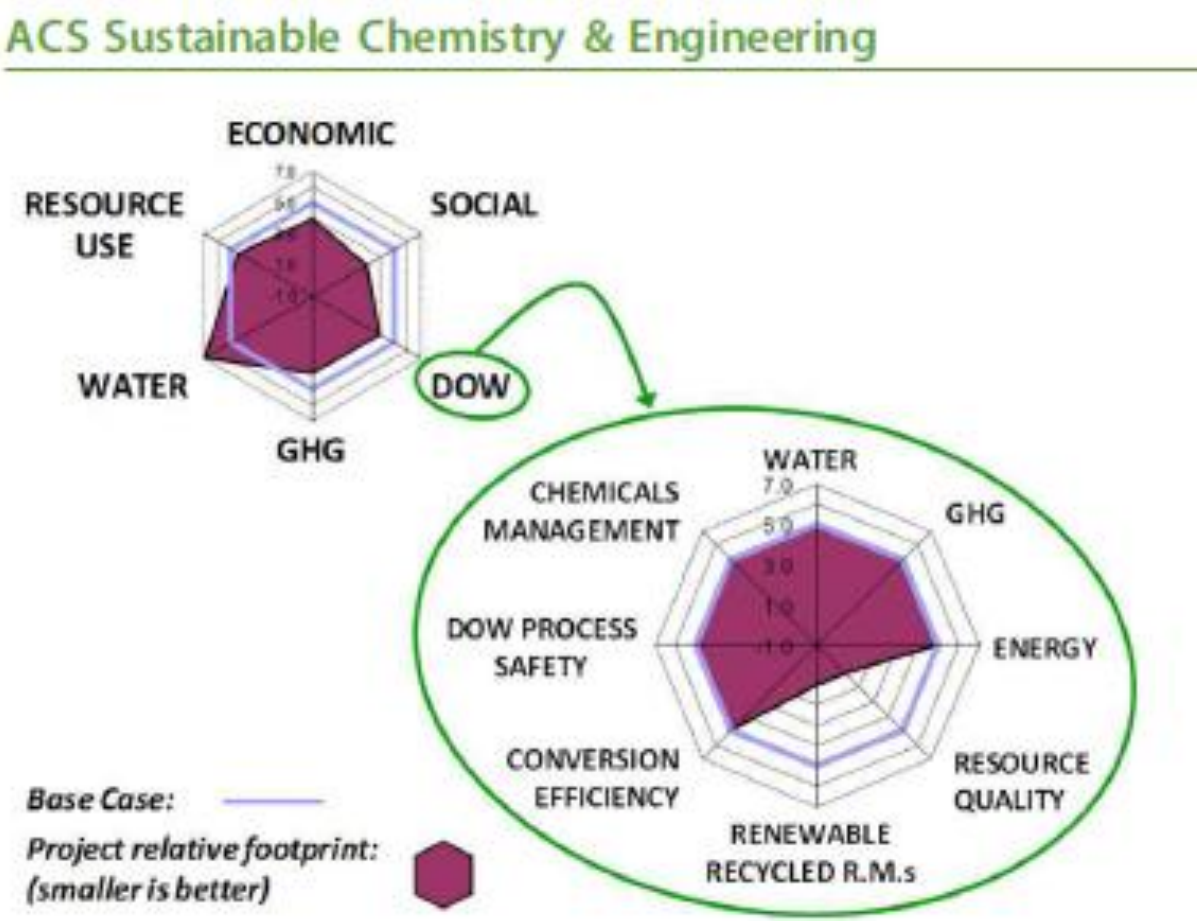
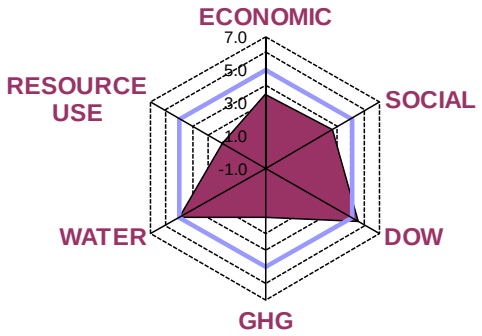
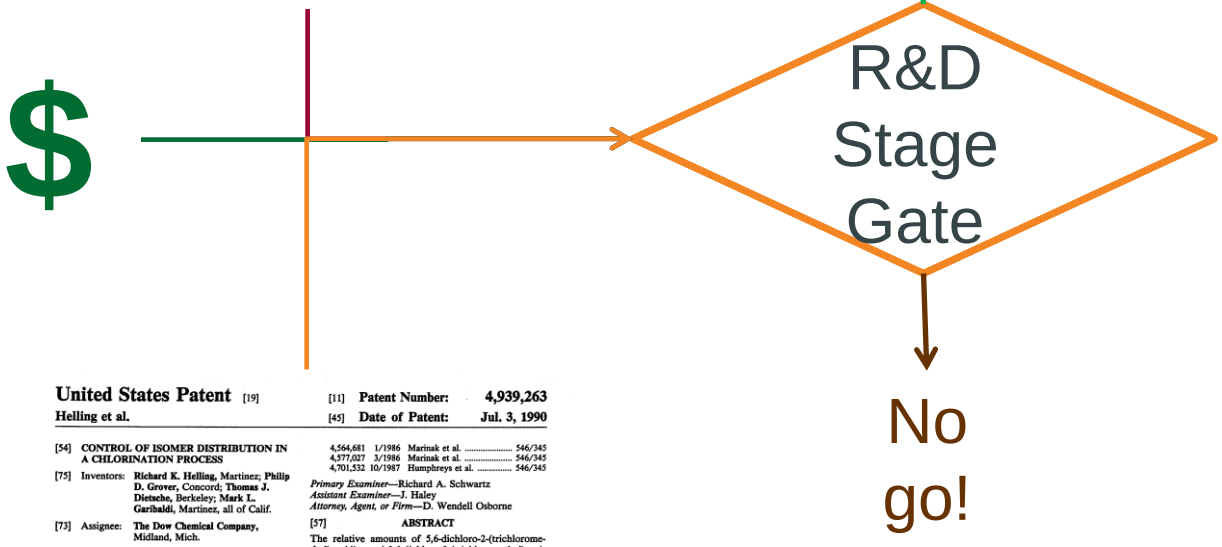


Figure 4. DCSFT assessment illustrating sustainability trade-offs for a biobased developmental composite.

Use of tool in R&D decisions





United States Patent [19]
Helling et al.

[11] **Patent Number: 4,939,263**
[45] **Date of Patent: Jul. 3, 1990**

[54] **CONTROL OF ISOMER DISTRIBUTION IN A CHLORINATION PROCESS**

[75] Inventors: **Richard K. Helling**, Martinez; **Philip D. Grover**, Concord; **Thomas J. Dietsche**, Berkeley; **Mark L. Garibaldi**, Martinez, all of Calif.

[73] Assignee: **The Dow Chemical Company**, Midland, Mich.

[21] Appl. No.: **413,926**

[22] Filed: **Sep. 28, 1989**

[51] **Int. Cl.**[5] **C07D 213/61**
[52] **U.S. Cl.** **546/345**
[58] **Field of Search** 546/345

[56] **References Cited**
U.S. PATENT DOCUMENTS

3,418,323	12/1968	Johnston et al.	546/345
3,732,230	5/1973	Brewer et al.	546/345
4,227,001	10/1980	Dietsche et al.	546/345
4,256,894	3/1989	Dietsche et al.	546/345
4,487,935	12/1984	Marinak et al.	546/345
4,564,681	1/1986	Marinak et al.	546/345
4,577,027	3/1986	Marinak et al.	546/345
4,701,532	10/1987	Humphreys et al.	546/345

Primary Examiner—Richard A. Schwartz
Assistant Examiner—J. Haley
Attorney, Agent, or Firm—D. Wendell Osborne

[57] **ABSTRACT**

The relative amounts of 5,6-dichloro-2-(trichloromethyl)pyridine and 3,6-dichloro-2-(trichloromethyl)pyridine obtained in the chlorination of 2-chloro-6-(trichloromethyl)pyridine in the liquid phase at temperatures of about 160° C. to about 220° C. and in the presence of a metal halide catalyst, such as ferric chloride, are controlled by regulating the amount of hydrogen chloride present in the system, adding hydrogen chloride to obtain a mixture enriched in 5,6-dichloro-2-(trichloromethyl)pyridine or removing hydrogen chloride, usually by passing excess chlorine or an inert gas through the system, to obtain a mixture enriched in 3,6-dichloro-2-(trichloromethyl)pyridine.

12 Claims, No Drawings

Life cycle assessment aids decisions

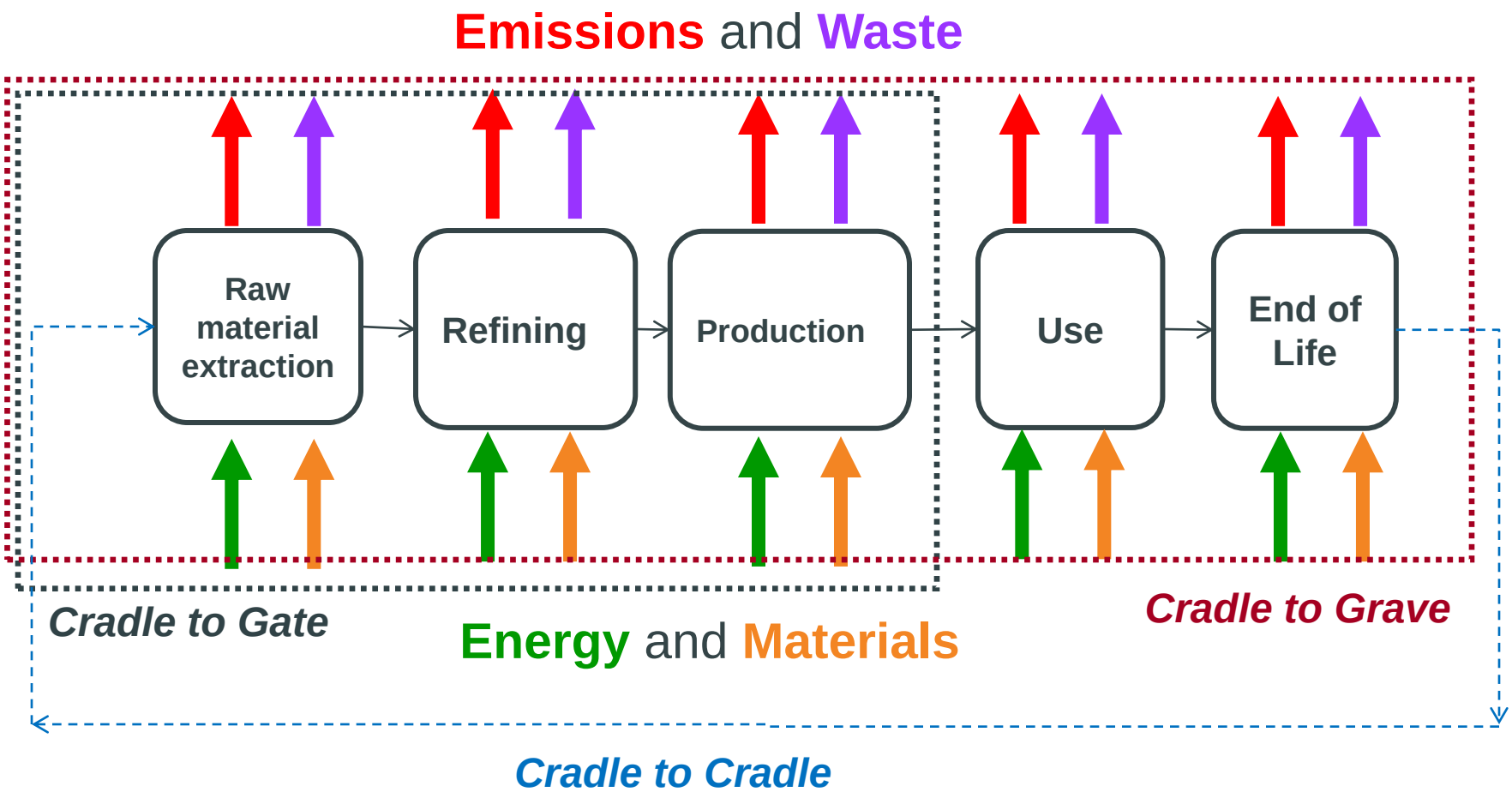
Support decision making

- **Drive innovation & sustainability**
- **Support marketing claims**
- **Facilitate customer discussions**

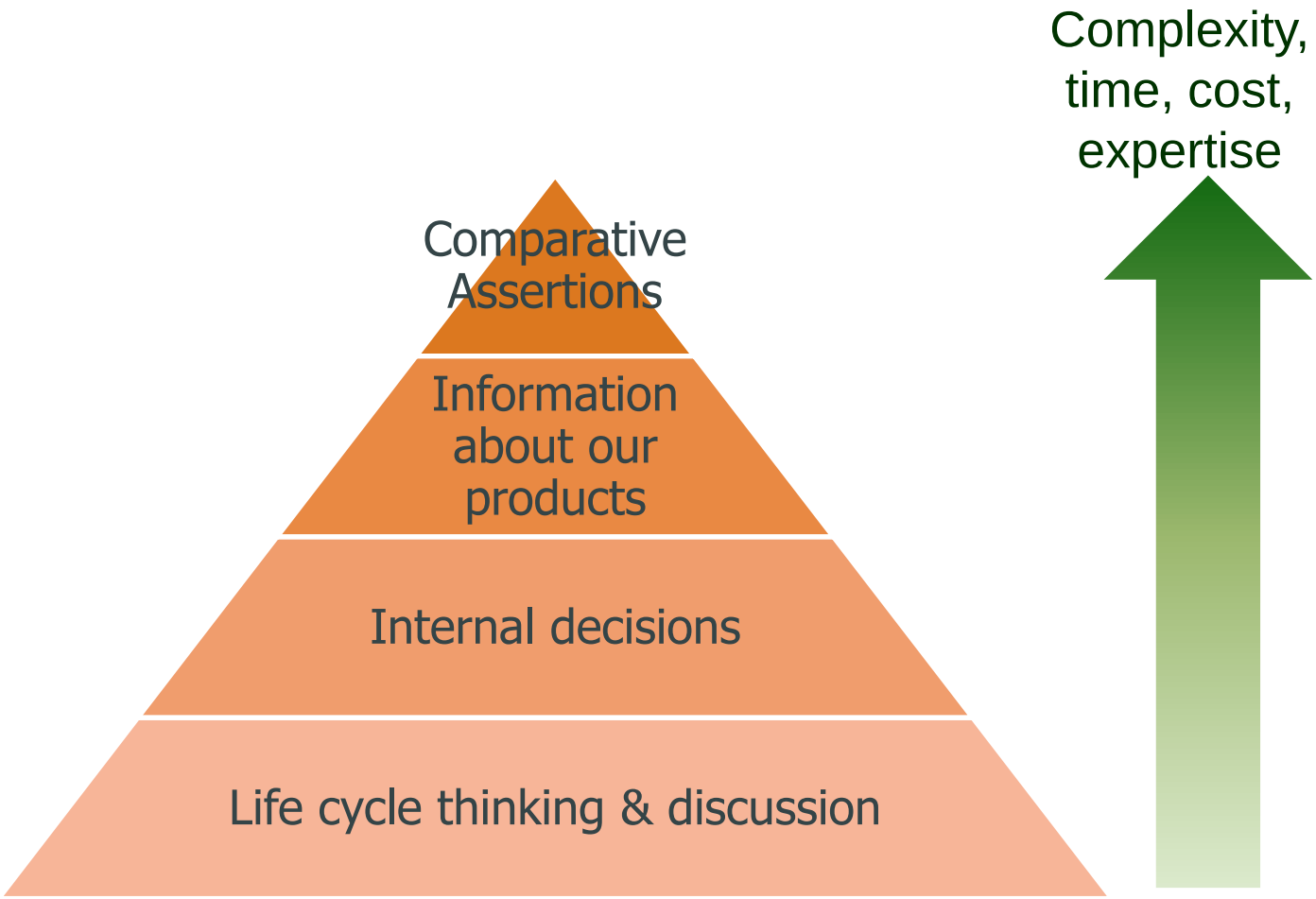
Generate:

- **Public reports**
- **Marketing literature**
- **EPDs (Environmental Product Declarations)**

Life cycle assessment concepts



The LCA pyramid



What if we could make films with low-density core?

*not the actual product, but a good picture!

Quick LCA results for low-density cores

metric	Current technology	Foam core option 1	Foam core option 2
Global warming potential			
Ozone depletion potetial			
Photo-chemical oxidant creation potential			
acidification potential			
Freshwater eutro-phication potential			
Agricultural land occupation			
Water depletion			
Marine eutrophication			
Fossil depletion			

~1 day work

~1 day for report

What if we used non-fossil filler for polyethylene films?

Quick LCA results for PE fillers

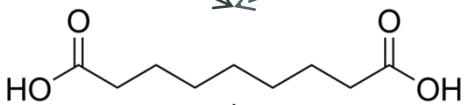
metric	Current Technology	Inorganic filler	Organic filler 1	Organic filler 2
Global warming potential				
Ozone depletion potetial				
Photo-chemical oxidant creation potential				
acidification potential				
Freshwater eutro-phication potential				
Agricultural land occupation				
Water depletion				
Marine eutrophication				
Fossil depletion				

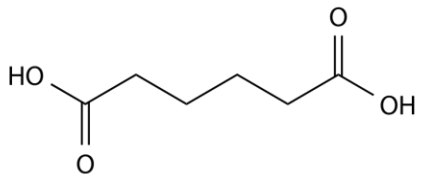
-1 day work

-1 day for report

Many roads to shoe soles…

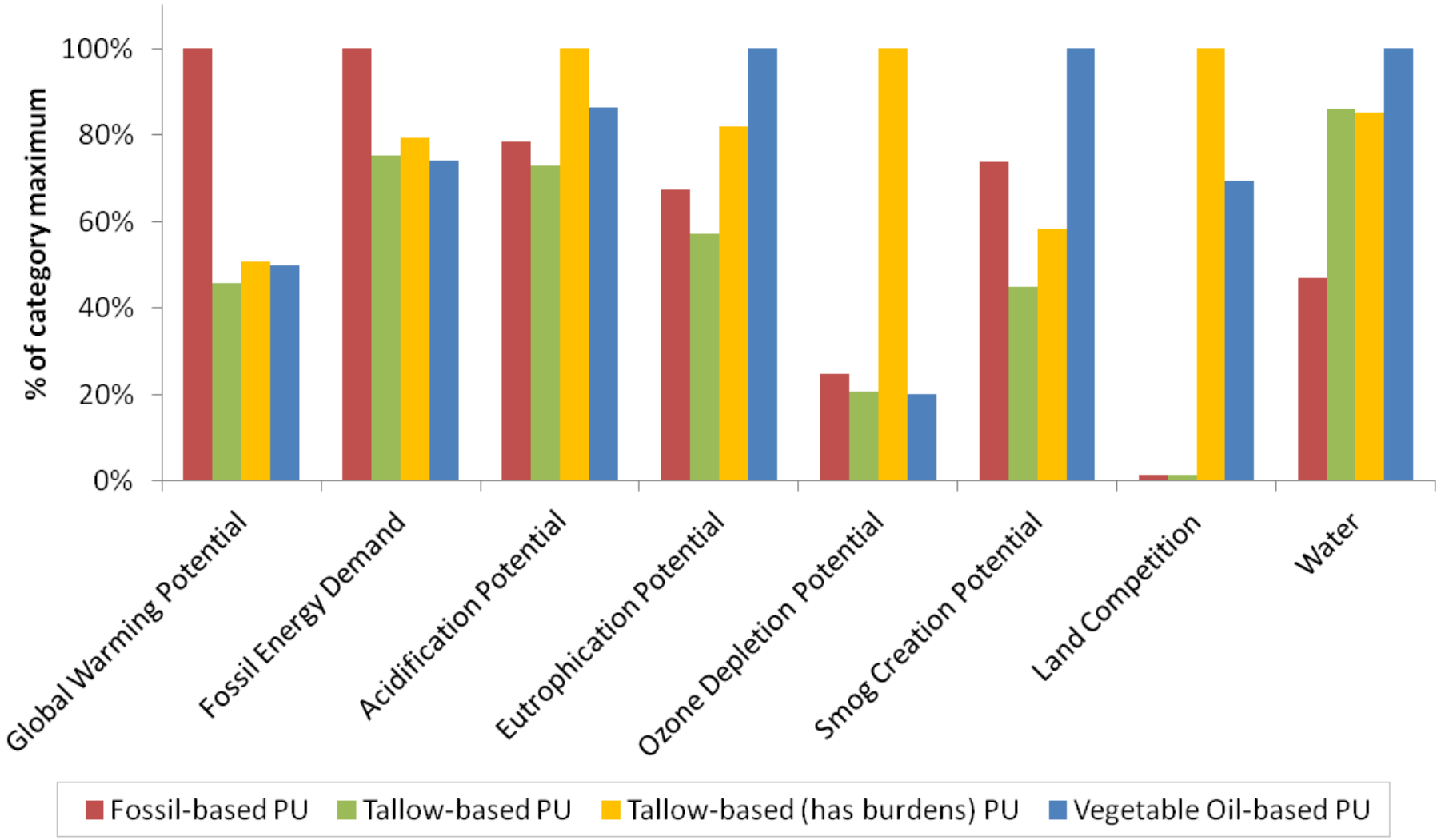
Azelaic acid



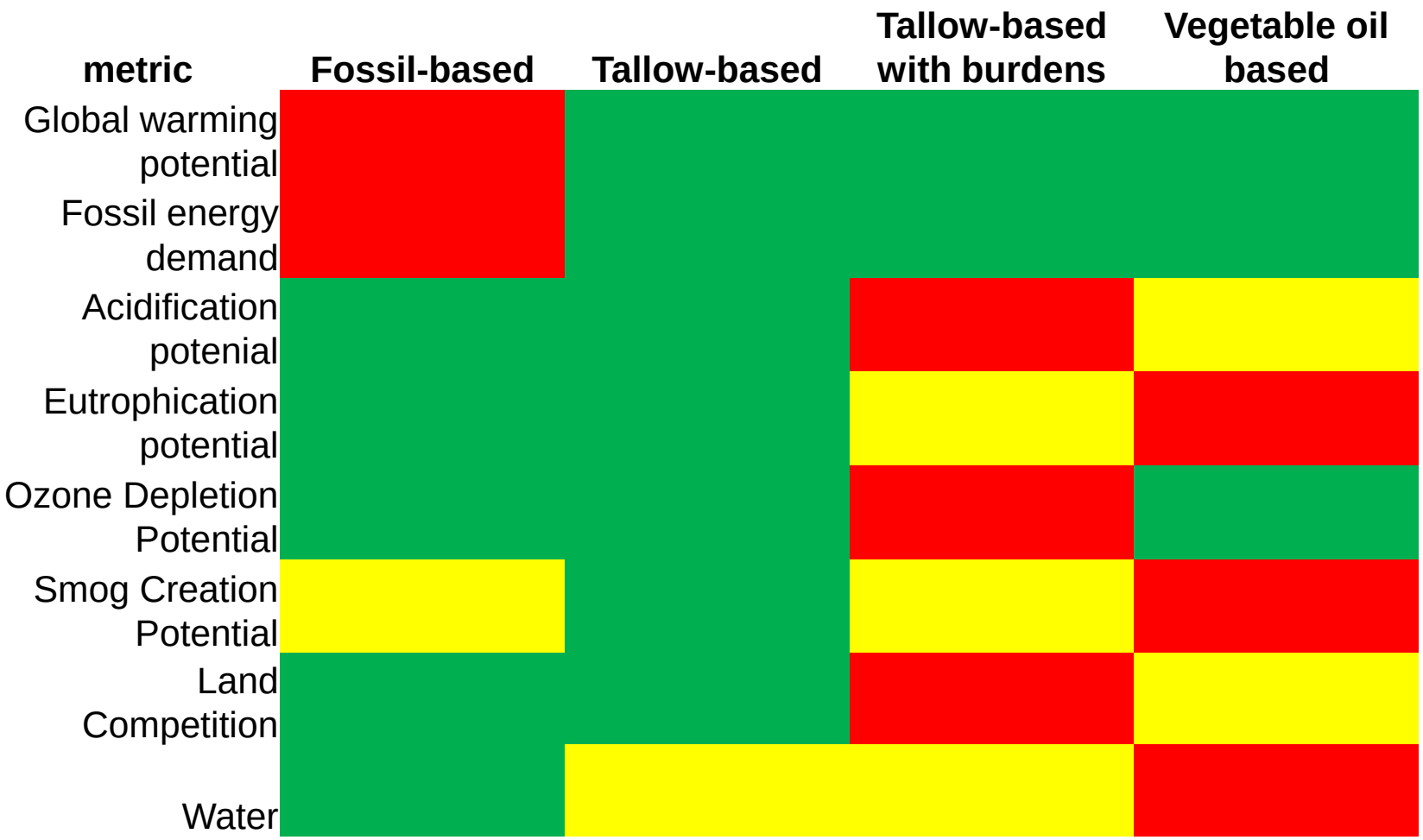


Adipic acid

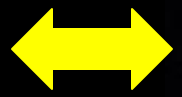
Results depend on choice of feedstock!



Results depend on choice of feedstock!



Elevate to the Macro Level

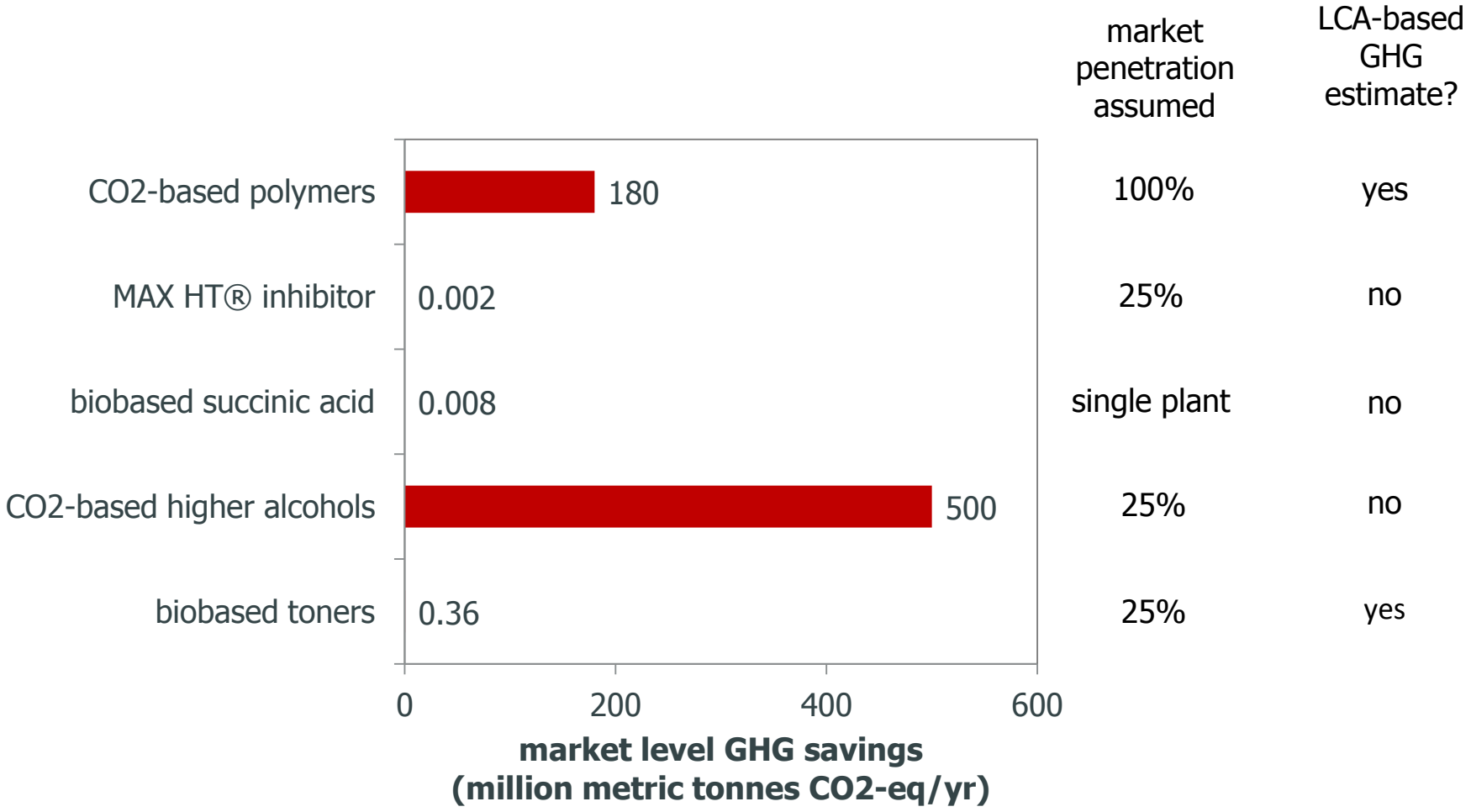


Market level analysis: a very simple concept

Product Benefit × A Market Volume = A Potential Market Level Benefit

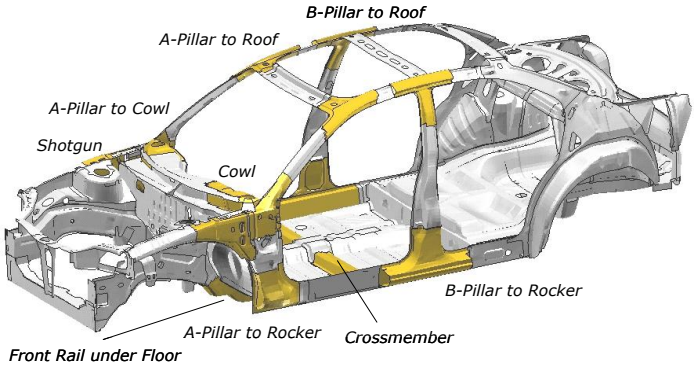
Hunter, Shawn, and Richard K. Helling “A Call for Technology Developers to Apply Life Cycle and Market Perspectives to Understanding the Potential Environmental Impacts of Chemical Technology Projects”, *Industrial & Engineering Chemistry Research*, on-line 26 January (**2015**)
DOI: 10.1021/ie504102h

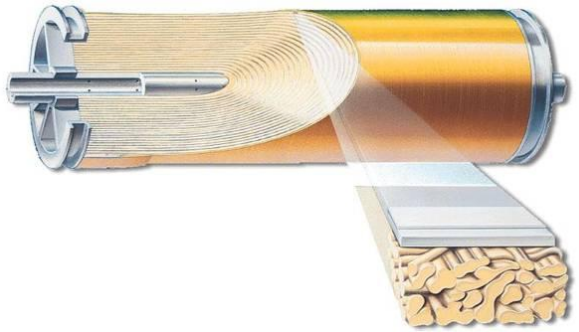
Estimated market benefit of Green Chemistry Award-winning projects



Data from: *Presidential Green Chemistry Challenge: Award Recipients 1996-2013*. United States Environmental Protection Agency, Washington, DC, 2014.

Innovative product examples





Summary

- Chemistry and technology can contribute to the transition to a sustainable society
- Life cycle thinking and LCA helps us to understand which solutions are better
  - Future vision
  - Individual awareness
  - Quantitative understanding for projects, products, businesses & the corporation
- Market level analysis helps us to understand which solutions have greatest potential to benefit society

Thank You

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